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INVENTORIED AIR POLLUTION EMISSIONS OF SULPHUR DIOXIDES, NITROGEN OXIDES AND VOLATILE ORGANIC COMPOUNDS FOR THE PROVINCE OF ONTARIO (1980 - 1983)

REPORT No. ARB-187-86-AQM

MAY, 1986

Ministry of the Environment

Dr. David Balsillie, Director
Air Resources Branch

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Ontario Ministry of Environment
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EXECUTIVE SUMMARY

This report summarizes the emission into the atmosphere of sulphur oxides (SO_x) and nitrogen oxides (NO_x) from industrial, transportation, fuel combustion, fires and incineration sources in Ontario for the period 1980 to 1983.

The total anthropogenic (man-made) SO_x emission amounted to 1.764 million metric tons in 1980 and decreased in the following years, to a total of 1.278 million tonnes in 1983. Industrial (mostly non-ferrous smelters) and electric utilities were the highest SO_x-emitting sectors. Together they contributed over 95 per cent of the provincial SO_x total. About 0.6 million tonnes of anthropogenic NO_x were emitted each year. Transportation was the major contributor with about 0.360 million tonnes per year or 60 per cent of the totals. Other important sectors were industrial (over 10 per cent) and electric utilities (about 20 per cent contribution).

Emissions of volatile organic compounds (VOC) from anthropogenic sources in Ontario in 1980 have also been estimated and are included in this report.

1. INTRODUCTION

The Ontario Emission Inventory System (OEIS) is a computerized data management system that accepts, stores and reports on recent available emissions information covering sulphur oxides, nitrogen oxides, hydrocarbon and other pollutants. The emission data can be spatially and temporally resolved. The analysis in this report of the current emissions is aimed at the following objectives:

a) To present the relative proportion of emission contribution of the major source sectors in Ontario.

b) To identify and quantify the highest SO_x and NO_x emitters in Ontario.

c) To indicate the trends of SO_x and NO_x.

The data presented in this report refer to the emissions from anthropogenic (man-made) origins. The general terms of sulphur oxides (SO_x) and nitrogen oxides (NO_x) are used to denote the emissions calculated as sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) correspondingly.

2. SO_x EMISSIONS

2.1 SO_x Emissions in 1983

The total SOx emission in Ontario in 1983 is estimated to be about 1278 kilotonnes. Table 1 shows the relative contribution of the major sectors in the Ontario total SO_x emissions. More details are presented in Figures 1 and 2 for 1983. Among the point sources, the non- ferrous smelters emitted more than 538 kilotonnes and had the largest share (42 per cent). Electric utility generating stations ranked next with 438 kilotonnes (34 per cent). Iron Ore accounted for about 6 per cent and petroleum refineries another 5 per cent. Area sources were responsible for only about 5 per cent of the total emission. An additional breakdown of the area emissions is given in Figure 2. This shows that fuel combustion (mostly oil) for transportation and space heating was responsible for 99 per cent of these SO_x emissions. The SO_x emissions from structural fires, forest fires and waste incineration were negligible.

Table 2 lists the top 10 point sources with regard to SO_x emissions in 1983. Emissions from these plants exceeded one million tonnes and accounted for more than 85 per cent of the provincial total. Inco was the largest single emitter with 459 kilotonnes/year. Nanticoke and Lambton generating stations followed Inco in SO_x rank but each of their emissions were less than half that of Inco output.

2.2 SO_x Trend From 1980 To 1983

A decreasing trend was observed with SO_x emissions in Ontario as shown by the totals in Table 1. The total SO_x emissions were reduced by 28 per cent (-486 kilotonnes) when based on the 1980 level of 1.764 million tonnes. This was due to the industrial sector, or more specifically, the reduced operation of the

non-ferrous smelters in these years. The SO_x emitted by these smelters was cut by 398 kilotonnes or 43 per cent of the 1980 amount. On the other hand, a slight increase (about 10 per cent) of the utility emissions occurred in the same period. These two sectors had the greatest influence on setting the trend of the SO_x emitted in the province. The SO_x trends are graphically depicted in Figure 3. Present indications are that SO_x emissions have increased again slightly between 1983 and 1985. In response to the economic recovery. Preliminary estimates of SO_x emissions in Ontario for 1985 are about 1.5 million tonnes.

Details of each category emissions for the industrial sector as well as area sources are presented in Tables 3 and 4.

TABLE 1

SUMMARY OF SO_x EMISSIONS IN ONTARIO

FROM 1980 TO 1983

(1000 TONNES/YEAR)

SOURCES	1980	(%)	1981	(%)	1982	(%)	1983	(%)
Industrial	1,291	73	1,158	70	637	56	786	61
Electric Utilities	396	23	418	26	450	39	438	34
Fuel Combustion	37	2	34	2	24	2	20	2
Others	40	2	37	2	33	3	35	3
TOTAL	1,764	100	1,646	100	1,144	100	1,278	100

Fig 1: 1983 SOx PROVINCIAL TOTAL
(1.278 Mill. Tonnes)

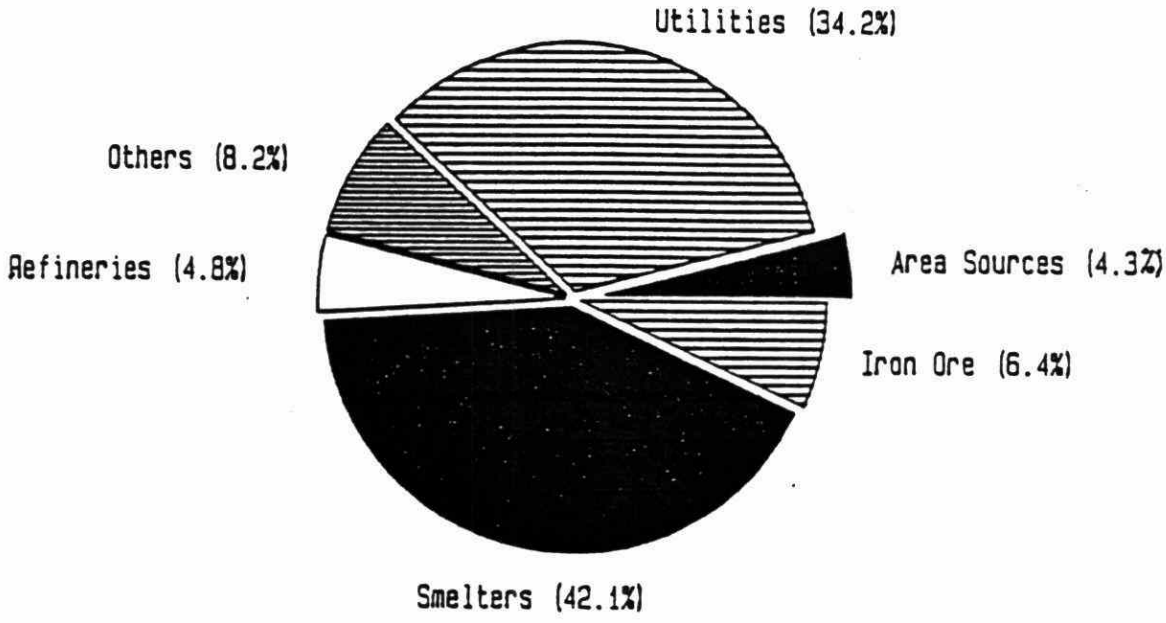


Fig 2: 1983 AREA SOx EMISSIONS
(54,646 Tonnes)

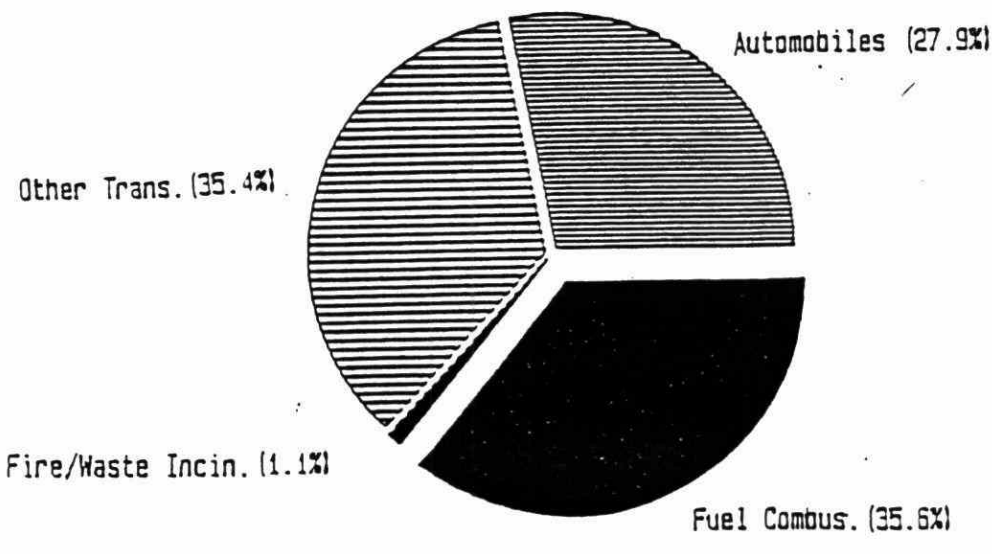


TABLE 2

ONTARIO EMISSION INVENTORY

TOP 10 POINT-SOURCES OF SO_x

1983

RANK	NAME	LOCATION	SO_x TONNES/YEAR
1	Inco	Sudbury	459,110
2	Nanticoke G.S.	Nanticoke	199,000
3	Lambton G.S.	Courtright	171,000
4	Algoma Ore Div.	Wawa	81,827
5	Falconbridge	Sudbury	78,897
6	Lakeview G.S.	Mississauga	56,600
7	Imperial Oil	Sarnia	22,900
8	Shell Canada Ltd.	Corunna	12,317
9	Thunder Bay G.S.	Thunder Bay	9,420
10	Algoma Steel Corp.	Sault Ste. Marie	7,299
		TOTAL	1,098,370

TABLE 3

ONTARIO SO_x EMISSIONS FROM INDUSTRIAL SOURCES

FROM 1980 TO 1983

(TONNES/YEAR)

CATEGORY	1980	1981	1982	1983
Non-Ferrous Smelters	935,451	836,172	388,773	538,007
Iron Ore (Wawa)	160,583	132,337	70,690	81,827
Iron & Steel	29,909	25,143	21,910	21,760
Electric Utilities	396,194	417,658	450,368	437,630
Petroleum Refineries	73,726	72,348	64,785	59,465
Pulp & Paper	31,303	31,303	31,303	31,361
Chemicals	8,141	8,543	7,784	5,453
Miscellaneous	51,443	51,765	51,421	47,829
TOTAL	1,686,750	1,575,271	1,087,034	1,223,333

Fig 3: 1980-1983 SOx EMISSION TREND

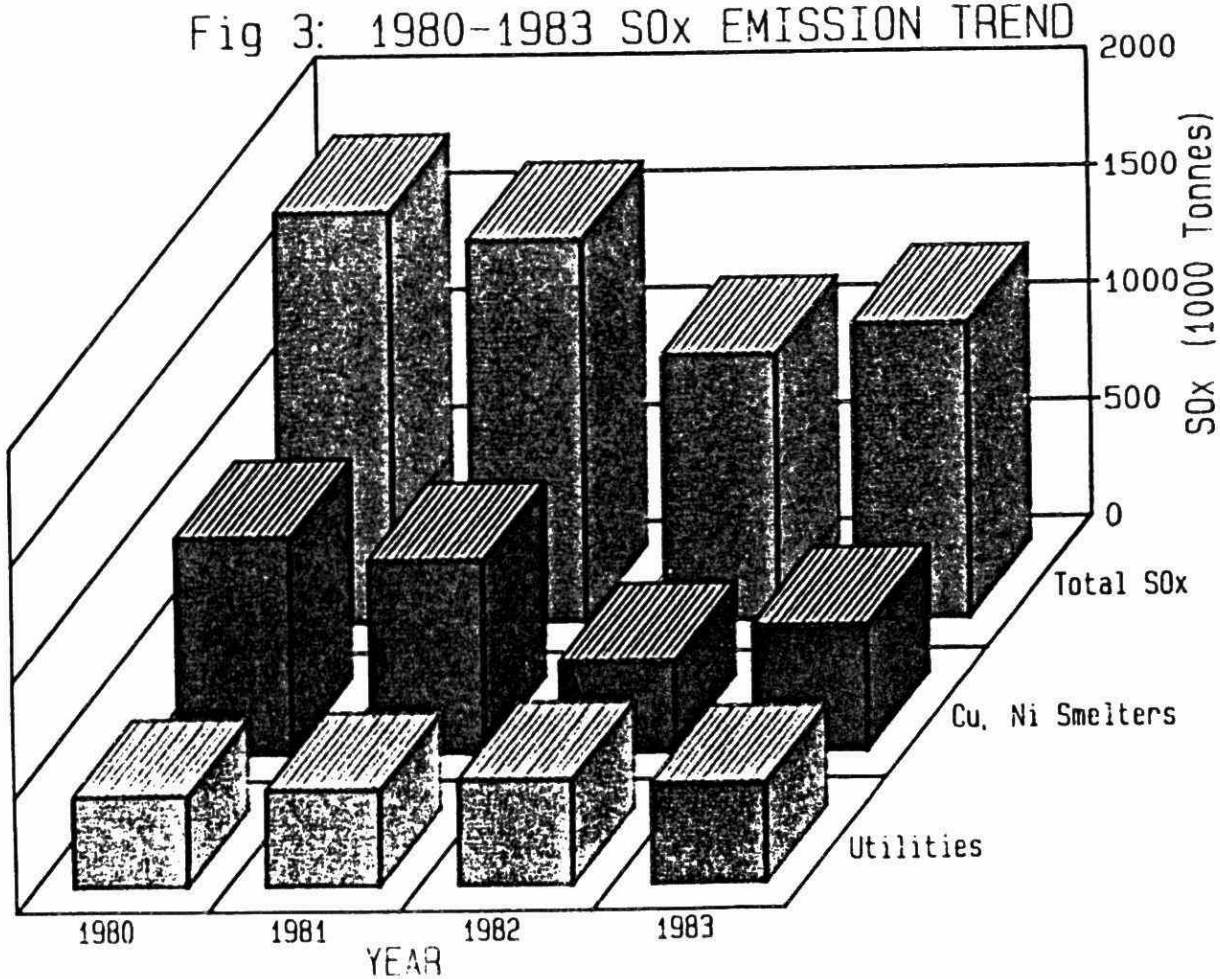


TABLE 4

ONTARIO AREA SO_x EMISSIONS FROM 1980 TO 1983

FROM 1980 TO 1983

(TONNES/YEAR)

CATEGORY	1980	1981	1982	1983
Total Vehicles	15,808	15,102	15,576	15,256
Off-Hwy. Engines	3,517	3,592	3,055	3,154
Railroad	4,564	4,809	4,525	4,580
Aircraft	173	173	165	163
Marine	15,360	12,299	8,714	11,429
Residential Heating	20,272	15,294	13,604	8,574
Comm/Inst. Heating	12,115	14,391	8,842	7,086
Industrial Heating	4,795	4,479	1,862	3,794
Waste Incineration	646	642	611	609
TOTAL	77,250	70,781	56,954	54,646

3. NO_x EMISSIONS

3.1 NO_x Emissions in 1983

The total NO_x emission in Ontario remained more or less the same as in previous years at about 600 kilotonnes as shown in Table 5. Figure 4 presents the major sectors of NO_x emissions, which include most notably area sources, electrical utilities and petroleum refineries. Area emissions accounted for 405 kilotonnes (68 per cent of the total), more than twice the NO_x amount emitted by all industrial point sources. A further breakdown of the area sources is shown in Figure 5. This reveals a large contribution by the transportation sector with 88 per cent of the area total. Emissions from automobiles alone were more than ten times those generated by space heating. In contrast to the SO_x scenario, non-ferrous smelter emissions were not critical and the top industrial NO_x polluters were the Ontario Hydro generating stations namely: Nanticoke, Lakeview and Lambton. The 10 largest NO_x point sources are listed in Table 6. Their NO_x total was responsible for about one quarter of the provincial amount in 1983.

3.2 NO_x Trend From 1980 To 1983

There were no dramatic changes in the total NO_x emissions during the period. One of the recognizable trends shown in Figure 6 was with the utility sector, which had an increase of about 20 per cent. This resulted from the emission of a single station, Nanticoke, whose NO_x emissions climbed steadily from 56 kilotonnes in 1980 to 75 kilotonnes in 1983 ($\pm$34 per cent). Future NO_x emissions at this station is expected to decline

with the introduction of new low-NO_x burners around the mid-eighties. The higher area NO_x emissions in 1980 and 1983, compared to 1981 and 1982, were the result of more forest fires occurring in those years.

Tables 7 and 8 present details of NO_x emissions from the main categories of the industrial sector and area sources respectively.

TABLE 5

SUMMARY OF NO_x EMISSIONS IN ONTARIO

FROM 1980 TO 1983

(KiloTONNES/YEAR)

SOURCES	1980	(%)	1981	(%)	1982	(%)	1983	(%)
Industrial	80	13	83	14	82	14	73	12
Electric Utilities	101	17	109	19	124	21	118	20
Transportation	367	60	356	60	358	60	355	60
Others*	58	10	42	7	32	5	50	8
TOTAL	606	100	590	100	596	100	596	100

* Including emissions from forest fires.

Fig 4: 1983 NOx PROVINCIAL TOTAL

(596, 100 Tonnes)

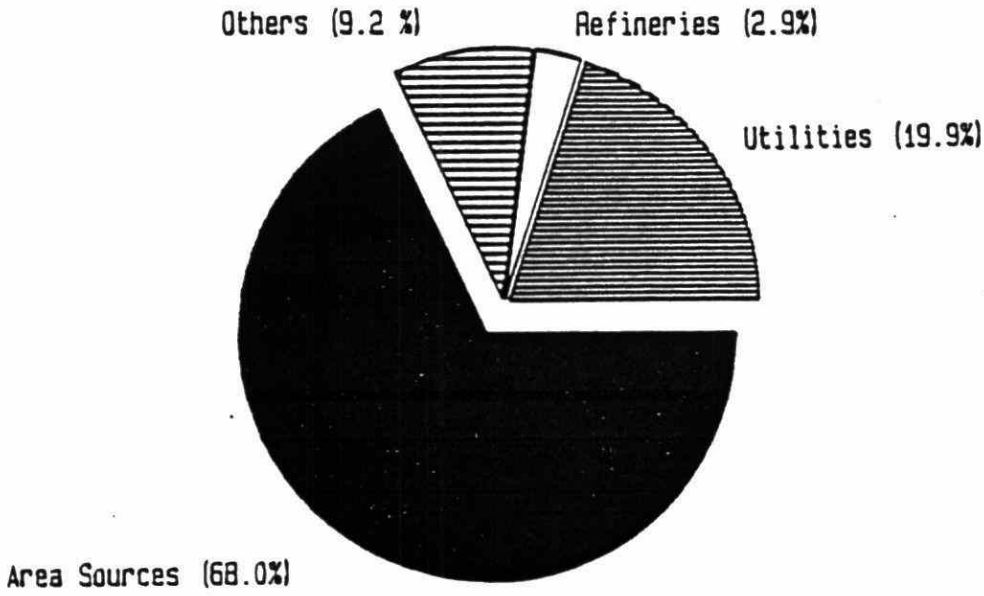


Fig 5: 1983 NOx AREA EMISSIONS

(405, 180 Tonnes)

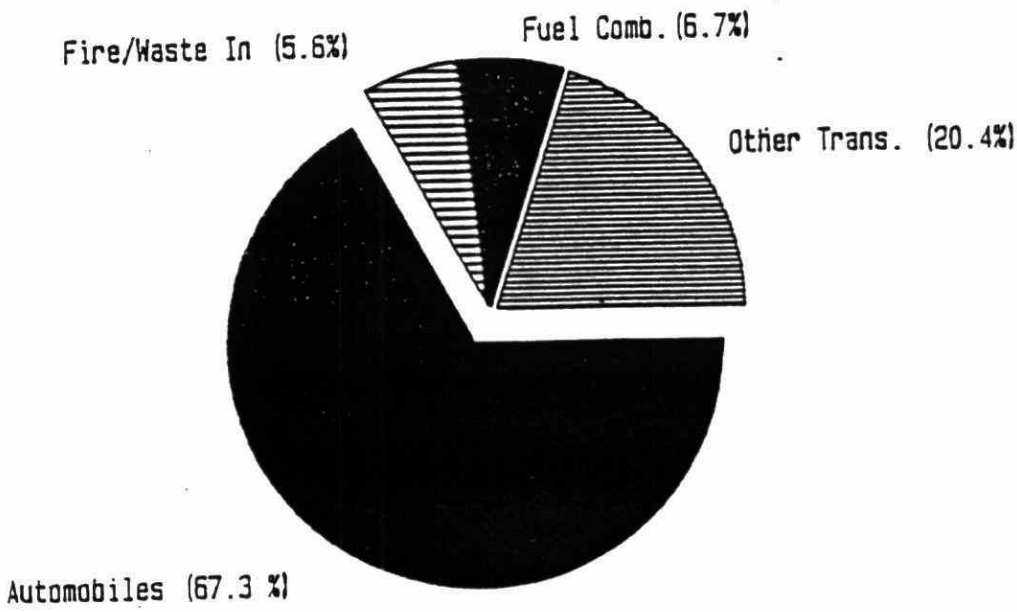


TABLE 6

ONTARIO EMISSION INVENTORY

TOP 10 POINT-SOURCES OF NO_x

1983

RANK	NAME	LOCATION	NO_x TONNES/YEAR
1	Nanticoke G.S.	Nanticoke	75,132
2	Lakeview G.S.	Mississauga	19,933
3	Lambton G.S.	Courtright	18,400
4	Petrosar Ltd.	Corunna	5,151
5	Stelco	Hamilton	5,000
6	Thunder Bay G.S	Thunder Bay	4,293
7	Imperial Oil	Sarnia	4,198
8	Dofasco	Hamilton	3,443
9	Algoma Steel Corp.	Sault Ste. Marie	2,826
10	Dow Chemical	Sarnia	2,727
		TOTAL	141,102

TABLE 7

ONTARIO NO_x EMISSIONS FROM INDUSTRIAL SOURCES

FROM 1980 TO 1983

(TONNES/YEAR)

CATEGORY	1980	1981	1982	1983
Non-Ferrous Smelters	2,530	2,930	2,930	2,930
Iron & Steel	12,118	15,705	15,705	11,309
Electric Utilities	100,976	108,992	123,549	118,426
Petroleum Refineries	23,214	19,380	19,315	17,449
Pulp & Paper	8,154	7,783	7,783	8,209
Chemicals	8,531	9,132	8,470	7,304
Other Manufactures	19,507	22,216	22,533	19,689
Miscellaneous Sources	5,357	5,580	5,580	5,580
TOTAL	180,387	191,718	205,865	190,895

TABLE 8

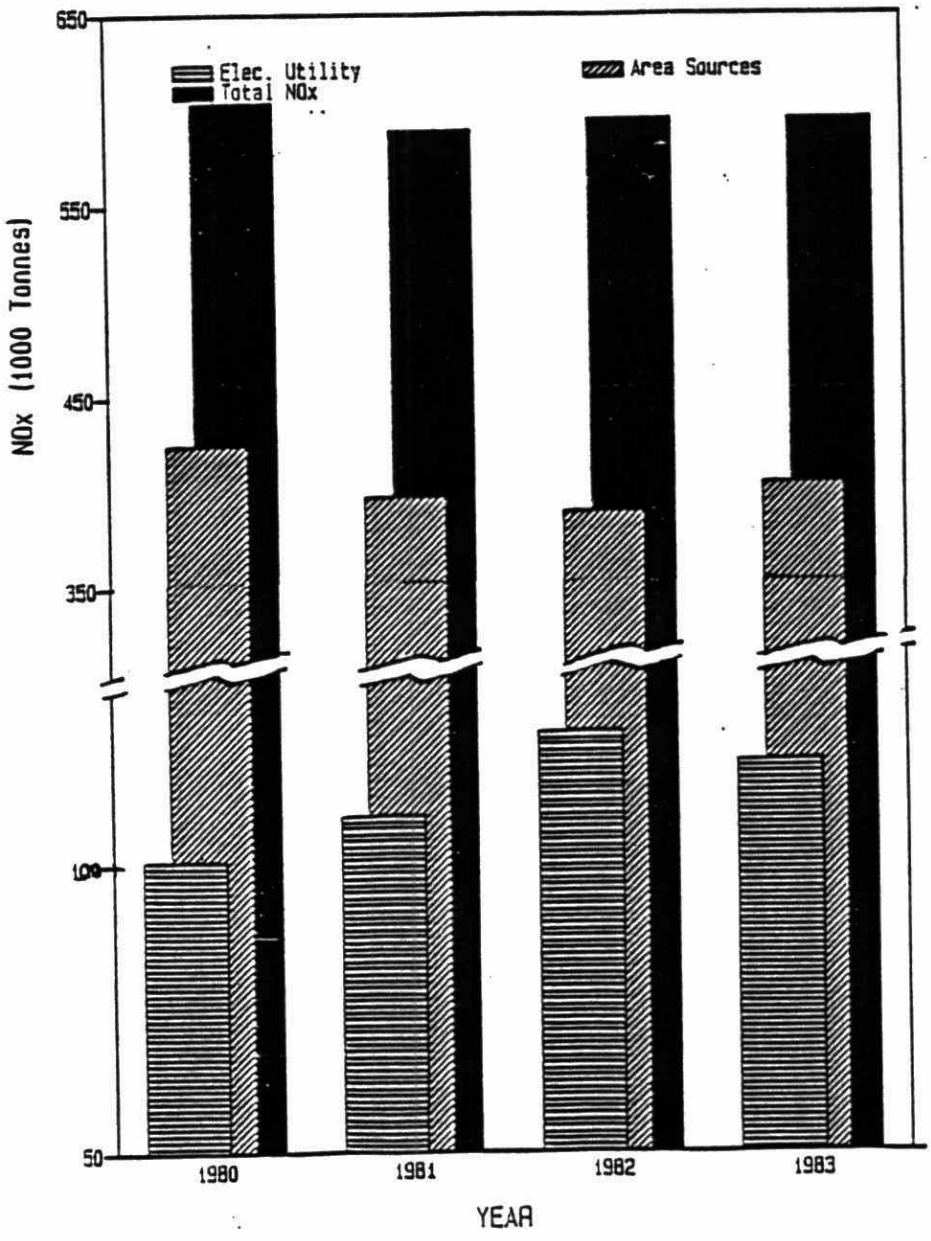
ONTARIO AREA NO_x EMISSIONS

FROM 1980 TO 1983

(TONNES/YEAR)

CATEGORY	1980	1981	1982	1983
Total Vehicles	277,836	265,866	279,421	272,495
Off-Hwy. Engines	49,191	50,584	42,360	43,847
Railroad	29,533	31,117	29,282	29,633
Aircraft	1,679	1,681	1,592	1,576
Marine	8,449	7,039	5,825	7,701
Residential Heating	18,626	17,237	16,837	14,711
Commercial Heating	10,007	11,772	10,549	10,210
Industrial Heating	2,187	2,005	1,145	2,356
Waste Incineration	2,662	2,643	2,593	2,580
Forest & Structural Fires	25,151	8,396	707	20,073
TOTAL	425,321	398,340	390,313	405,181

Fig 6: 1980-1983 NOx EMISSION TREND



4. VOLATILE ORGANIC COMPOUNDS (VOC) EMISSIONS

4.1 VOC Emissions in 1980

The total anthropogenic VOC emissions (excluding landfills) in Ontario were estimated to be about 664 kilotonnes. Of this amount, only 10 per cent was methane and the remaining 90 per cent was non-methane compounds. The contribution by the major source sectors to the 1980 VOC total emissions is illustrated in Figure 7 and Table 9. The most significant emissions came from transportation (257 kilotonnes), fuel combustion (122 kilotonnes) and general solvent usage (75 kilotonnes). The industrial sources contributed only 24 per cent of the total anthropogenic VOC emissions. Their breakdown, presented in Figure 8A, includes chemical manufacturing (67 kilotonnes), surface coating (28 kilotonnes) and petroleum refining (27 kilotonnes). Landfills which is another major source of VOC emission are estimated to be about 682 kilotonnes (over 98 per cent of which is methane).

In addition to anthropogenic emissions, a very significant amount of VOC was produced by natural sources such as vegetation, soils and wetlands. The total VOC emitted from natural sources was estimated to be about 28.9 million metric tonnes and over 80 per cent of this amount was methane gas. A relative comparison of the natural and major anthropogenic contributors is provided in Appendix 8B.

4.2 Spatial Distribution of Anthropogenic VOC Emissions

The distribution of total anthropogenic VOC emissions (excluding landfills) is presented in Figure 9. The average emission in Northern Ontario was less than 5 metric tonnes per square kilometer. However, some populated northern cities such as Thunder Bay and Sault Ste. Marie showed higher VOC levels.

The highest emissions occurred in Southern Ontario, especially in the Toronto-Hamilton and Sarnia-Windsor corridors. The latter contained dominant industrial sources with respect to VOC such as petroleum refineries, chemical manufactures, etc. The Toronto-Hamilton corridor, however, had the highest urban sources such as vehicles, gasoline marketing and solvent usage. If landfills were included, this area would have the highest VOC emission rate.

Figure 7: 1980 ONTARIO ANTHROPOGENIC VOC EMISSIONS

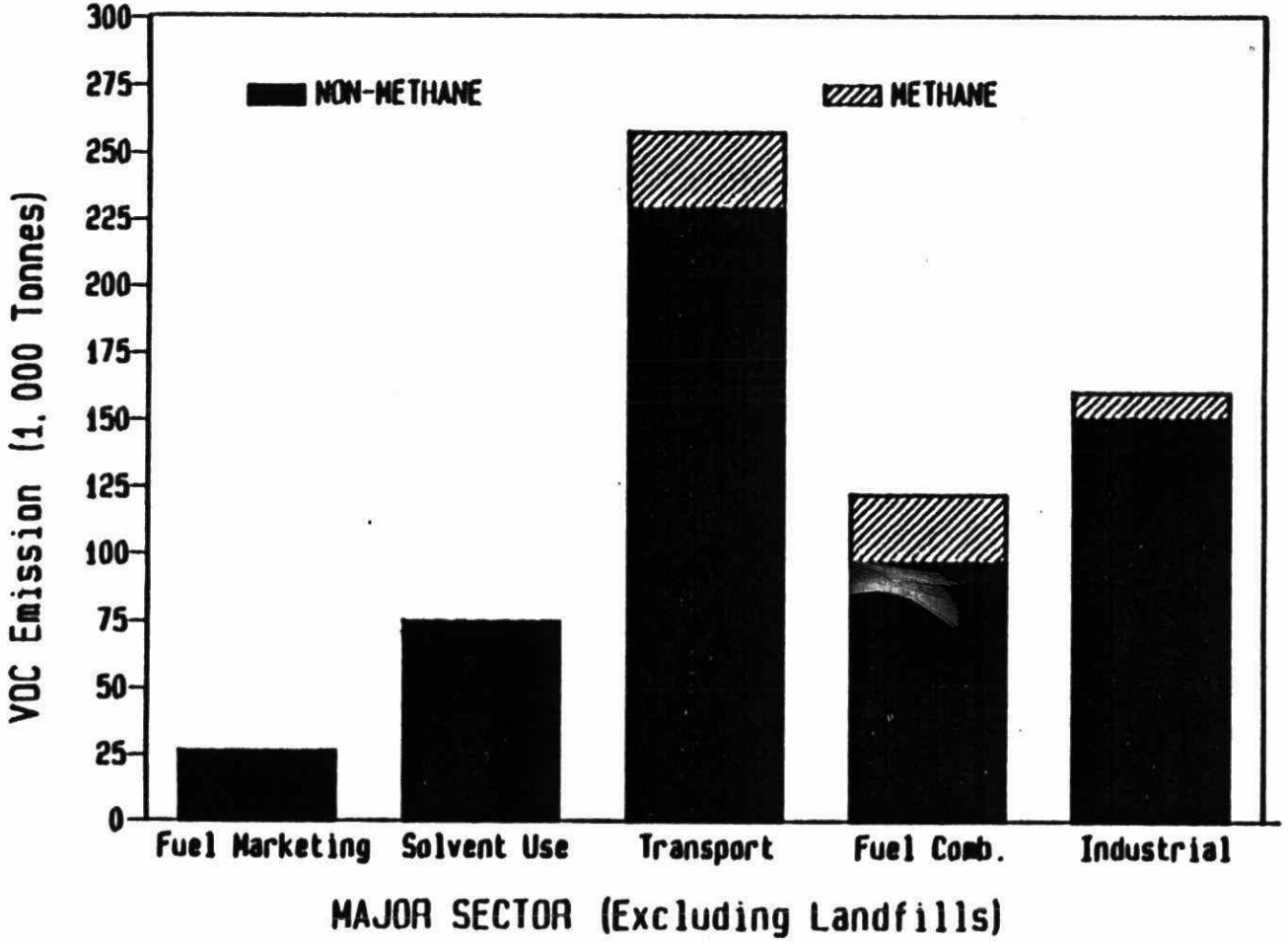


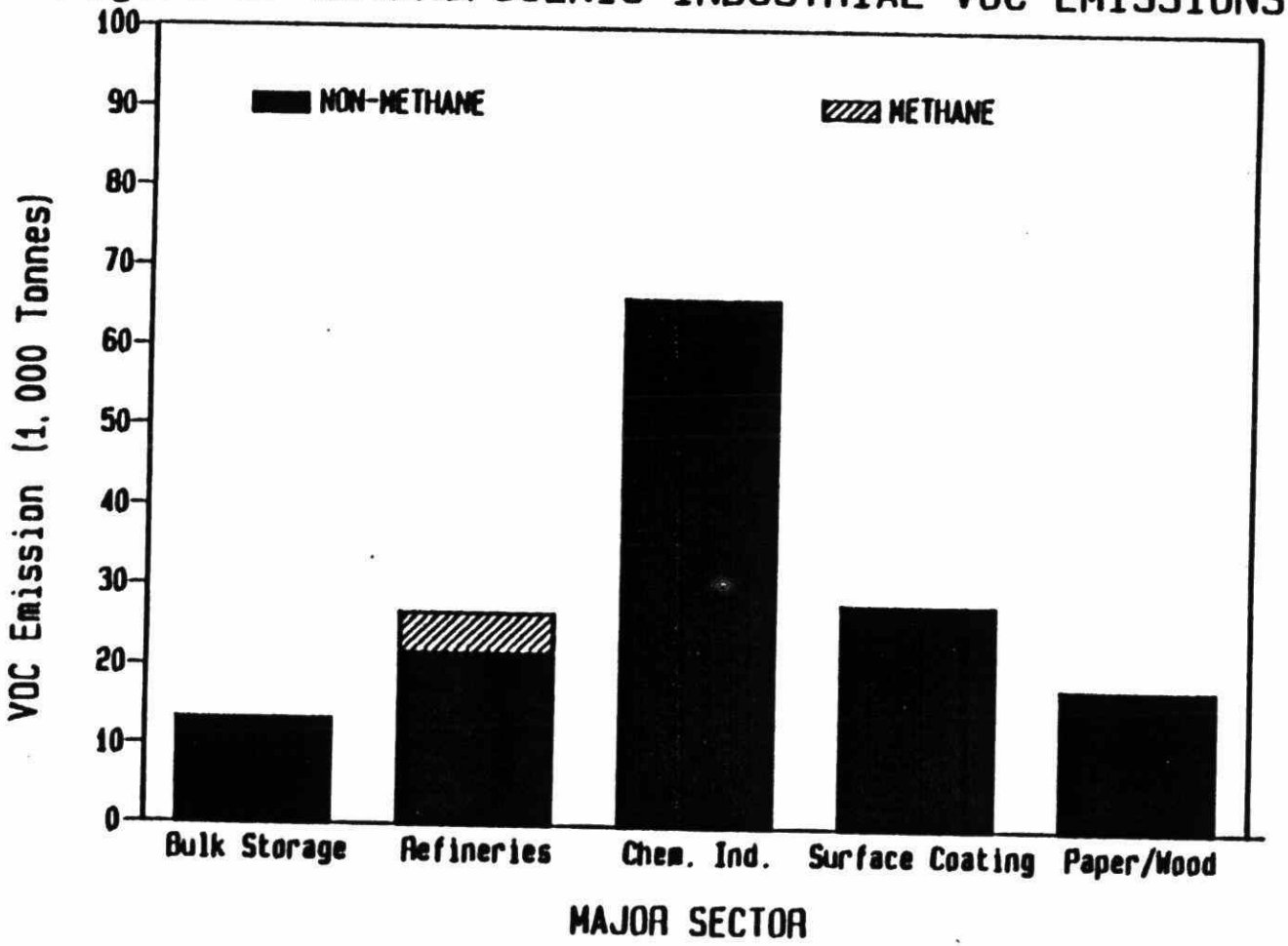
TABLE 9
ONTARIO VOC EMISSIONS IN 1980
(TONNES/YEAR)

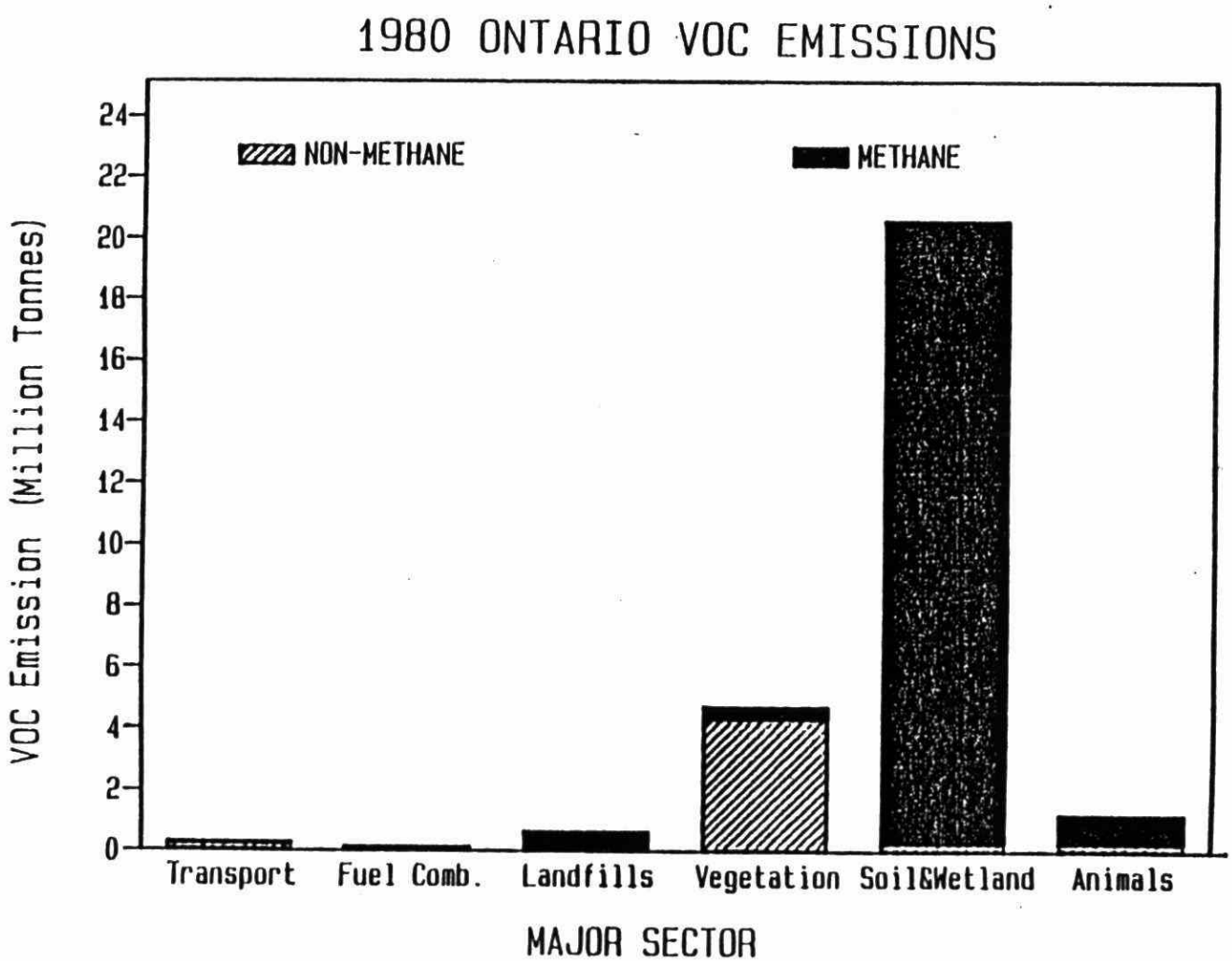
	CATEGORY	METHANE	NON-METANE	TOTAL
1.	ANTHROPOGENIC VOC			
	Fuel Marketing	0	26,484	26,484
	Solvent Use	1,079	74,328	75,407
	Transportation	28,750	228,319	257,069
	Fuel Combustion	25,189	96,493	121,682
	Miscellaneous	1,403	22,273	23,676
	Area Source Subtotal(*)	56,421	447,897	504,318
	Bulk Storage+	356	13,245	13,601
	Refineries	5,128	21,445	26,573
	Chemicals	805	66,069	66,874
	Surface Coating	0	28,015	28,015
	Paper/Wood	456	17,152	17,608
	Miscellaneous	3,275	4,281	7,556
	Point Source Subtotal	10,020	150,207	160,227
	ANTHOPOGENIC TOTAL (*)	66,441	598,104	664,545
2.	LANDFILL	664,515	17,885	682,400
3.	NATURAL VOC			
	Vegetation	395,535	4,316,633	4,712,168
	Soils and Wetlands	20,182,880	296,958	20,479,838
	Animals	909,219	274,818	1,184,037
	Miscellaneous	98,208	387,392	485,600
	NATURAL SOURCE TOTAL	21,585,842	5,275,801	26,861,643

(*) Landfills excluded

\+ Bulk Storage Emissions including vehicle fueling, gas tank loading/unloading/transit losses.

Figure 8: ANTHROPOGENIC INDUSTRIAL VOC EMISSIONS




1980 ONTARIO VOC EMISSIONS
NON-METHANE
METHANE
VOC Emission (Million Tonnes)
0
2
4
6
8
10
12
14
16
18
20
22
24
Transport
Fuel Comb.
Landfills
Vegetation
Soil&Wetland
Animals
MAJOR SECTOR

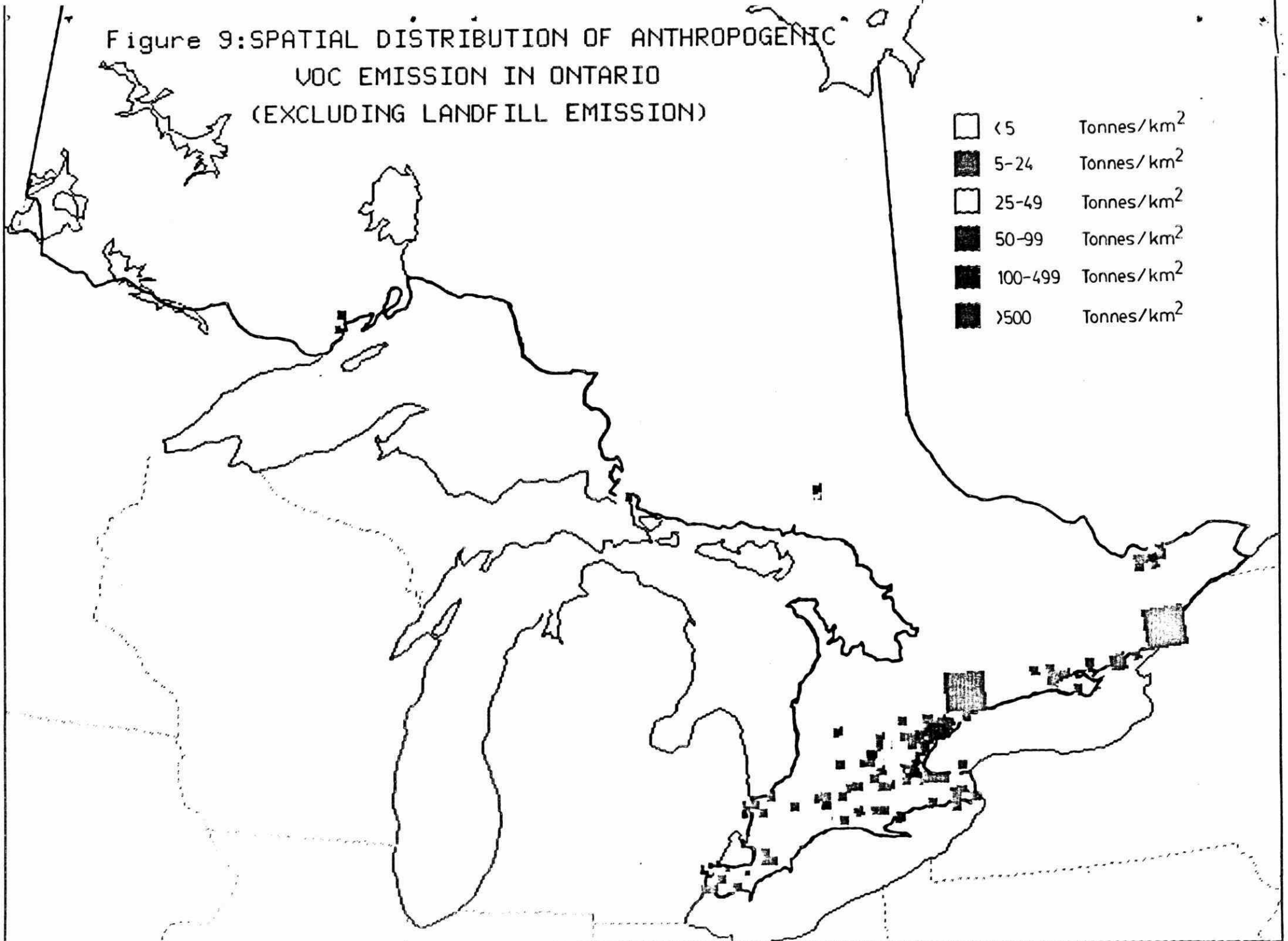


Figure 9:SPATIAL DISTRIBUTION OF ANTHROPOGENIC
VOC EMISSION IN ONTARIO
(EXCLUDING LANDFILL EMISSION)
<5 Tonnes/km2
5-24 Tonnes/km2
25-49 Tonnes/km2
50-99 Tonnes/km2
100-499 Tonnes/km2
>500 Tonnes/km2